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pH of BUFFER SOLUTIONS

EXAMPLE 1

A buffer solution was made by adding 2.05 g of sodium ethanoate to 0.500 dm³ of 0.01 mol dm⁻³ ethanoic acid. Calculate the pH of this solution (K_a for ethanoic acid = 1.74×10^{-5} mol dm⁻³).

$$\text{moles CH}_3\text{COONa} = \frac{2.05}{82.0} = 0.0250$$

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \quad [\text{H}^+] = \frac{K_a [\text{HA}]}{[\text{A}^-]}$$

$$[\text{H}^+] = \frac{1.74 \times 10^{-5} \times 0.01}{\frac{0.0250}{0.500}} = 3.48 \times 10^{-6}$$

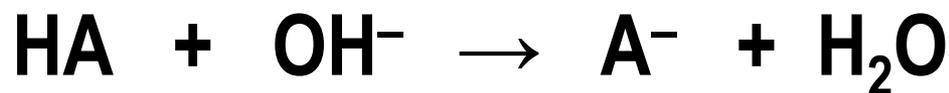
$$\text{pH} = -\log [\text{H}^+] = -\log 3.48 \times 10^{-6} = \mathbf{5.46}$$

EXAMPLE 2a

A buffer solution was made by mixing 25.0 cm³ of 1.00 mol dm⁻³ ethanoic acid with 25 cm³ of 0.400 mol dm⁻³ sodium hydroxide. Find the pH of this buffer. (K_a for ethanoic acid = 1.74×10^{-5} mol dm⁻³).

$$\text{moles HA} = 1.00 \times \frac{25.0}{1000} = 0.0250$$

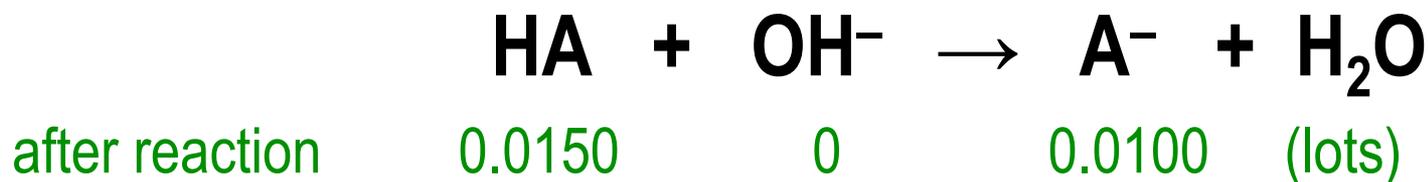
$$\text{moles OH}^- = 0.400 \times \frac{25}{1000} = 0.0100$$



before reaction	0.0250	0.0100	0	(lots)
change	-0.0100	-0.0100	+0.0100	(+0.0100)
after reaction	0.0150	0	0.0100	(lots)

EXAMPLE 2a

A buffer solution was made by mixing 25.0 cm³ of 1.00 mol dm⁻³ ethanoic acid with 25 cm³ of 0.400 mol dm⁻³ sodium hydroxide. Find the pH of this buffer. (K_a for ethanoic acid = 1.74×10^{-5} mol dm⁻³).



$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \quad [\text{H}^+] = \frac{K_a [\text{HA}]}{[\text{A}^-]}$$

$$[\text{H}^+] = \frac{1.74 \times 10^{-5} \times \frac{0.0150}{\frac{50}{1000}}}{\frac{0.0100}{\frac{50}{1000}}} = 2.61 \times 10^{-5}$$

$$\text{pH} = -\log [\text{H}^+] = -\log 2.61 \times 10^{-5} = \mathbf{4.58}$$

EXAMPLE 2b

Calculate the new pH of the buffer if 0.2 cm³ of 0.50 mol dm⁻³ sulfuric acid is added to the sample from part (a).

$$\text{moles H}^+ \text{ added} = 2 \times 0.50 \times \frac{50.0}{1000} = 0.00020$$

	A⁻	+	H⁺	→	HA
before reaction	0.0100		0.00020		0.0150
change	-0.00020		-0.00020		+0.00020
after reaction	0.0098		0		0.0152

EXAMPLE 2b

Calculate the new pH of the buffer if 0.2 cm³ of 0.50 mol dm⁻³ sulfuric acid is added to the sample from part (a).



after reaction 0.0098 0 0.0152

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \quad [\text{H}^+] = \frac{K_a [\text{HA}]}{[\text{A}^-]}$$

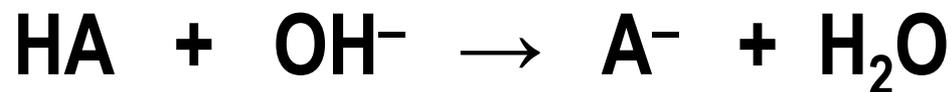
$$[\text{H}^+] = \frac{1.74 \times 10^{-5} \times \frac{0.0152}{\frac{50.2}{1000}}}{\frac{0.0098}{\frac{50.2}{1000}}} = 2.70 \times 10^{-5}$$

$$\text{pH} = -\log [\text{H}^+] = -\log 2.70 \times 10^{-5} = 4.57$$

EXAMPLE 2c

Calculate the new pH of the buffer if 1.0 cm³ of 0.100 mol dm⁻³ sodium hydroxide is added to the sample from part (a).

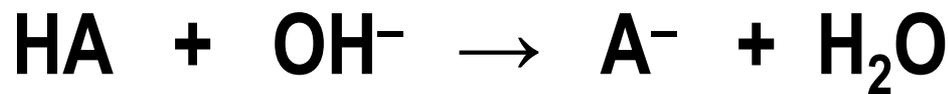
$$\text{moles OH}^- \text{ added} = 0.100 \times \frac{1.0}{1000} = 0.00010$$



before reaction	0.0150	0.00010	0.0100	(lots)
change	-0.00010	-0.00010	+0.00010	(+0.00010)
after reaction	0.0149	0	0.0101	(lots)

EXAMPLE 2c

Calculate the new pH of the buffer if 1.0 cm³ of 0.100 mol dm⁻³ sodium hydroxide is added to the sample from part (a).



after reaction 0.0149 0 0.0101 (lots)

$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]} \quad [\text{H}^+] = \frac{K_a [\text{HA}]}{[\text{A}^-]}$$

$$[\text{H}^+] = \frac{1.74 \times 10^{-5} \times \frac{0.0149}{\frac{51.0}{1000}}}{\frac{0.0101}{\frac{51.0}{1000}}} = 2.57 \times 10^{-5}$$

$$\text{pH} = -\log [\text{H}^+] = -\log 2.57 \times 10^{-5} = 4.59$$